Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of:	)	
	)	
	)	RM-11306
	)	
Amendment of Part 97 of the Commission's Rules Governing the Amateur Radio Services	)	
	)	
By Edwin C. Jones, MD, PhD AE4TM	)	
	)	

TO: The Chief, Wireless Telecommunications Bureau
VIA OFFICE OF THE SECRETARY

REPLY TO THE COMMENTS OF CQ COMMUNICATIONS INC.

The following is my reply, submitted in accordance with 47CFR§1.405(b).

Discussion: The well thought out comment by CQ Communications Inc. is in general agreement with the ARRL petition RM-11306. However, the comment does raise one concern in regards to interference caused by "semi-automatic digital stations" (stations under local or remote control per Part 97.221). I am replying to the CQ Communications, Inc. comment regarding concern over the use of this technology in the amateur bands. In my opinion, I present two arguments that I believe should support the ARRL petition, RM-11306, regarding the deletion of 97.221(c) for "semi-automatic digital stations" (stations under local or remote control).

First, unlike VHF, UHF, or microwave communications transmissions, a telecommunications rule coined *the "Rule of Recroprocity" pertaining to these higher frequency ranges does not apply to the lower HF and MF frequencies.* The "Rule of Recroprocity" states that two communications stations transmitting equal RF powers that are in line-of-sight of each other will observe the same signal strength on receive regardless of the antenna differences between the two individual stations. In contrast, unlike line-of-sight communications, HF and MF communications rely on the ionosphere for long distance propagation, and the nature of the ionosphere breaks down this rule.

The ionosphere being plasma with both electrons and positive ions trapped in a magnetic field has a resulting interesting property that voids the "Rule of Recroprocity." In essence, differences in polarization factors between different ionospheric locations cause the ionosphere to support *both birefringent and anisotropic propagation.* This propagation property was shown mathematically by Dr. J. D. Jackson who solved the Equation of Motion for ionospheric radio wave propagation.[1] A brief outline to his approach is shown in Appendix A.

Because the ionosphere supports *birefringent and anisotropic propagation*, two communications stations with identical transmitters and antennas that rely on the ionosphere for propagation do not necessarily receive similar signal strengths from each other. Furthermore, in extreme limits, the communications can even be one-way. When these propagation conditions are observed, some radio operators might attribute these events to intentional interference when in fact they are a fundamental phenomenon related to polarization effects within the ionosphere.

Second, interference between SSB and Pactor used in "semi-automatic" mode will be mutual. Pactor-II/III are advanced digital modes capable of operating down to -18 dB S/N ratios (as measured on a 4kHz noise bandwidth)[2], a level well below the audible level of normal human ears. Therefore, although easily copied by other Pactor modems, when the propagation conditions are poor Pactor-II/III often goes unnoticed by human hearing. As a result, a SSB station will likely initiate a voice contact on top of an existing digital contact because the channel *appears* clear to human hearing. Furthermore, due to the poor propagation conditions a SSB contact will likely require a linear amplifier exacerbating the interference to a Pactor contact. When such SSB contacts are made over unheard Pactor contacts, the resulting RF background levels increase pushing the Pactor-II/III connects to even lower S/N levels. When the level is pushed below the -18dB S/N sensitivity cutoff, the Pactor link is broken without the SSB operator even being aware of what has happened.

When considering the larger number of SSB operators worldwide, compared to number of Pactor operators worldwide, the statistical chance of

[1] J.D. Jackson in "Classical Electrodynamics," Second Edition (Wiley, New York, 1975), pp. 292-296.

[2] Hans-Peter Helfert DL6MAA (main inventor of Pactor), http://www.scs-ptc.com/controller.html

interference from SSB communications to Pactor communications is therefore far greater by the following relative rate:

> Relative interference rate ~ [S / (S+P)], where
> S = total number of active SSB stations worldwide, and
> P = total number of active Pactor stations worldwide.

These mutual interference issues are not only a concern to SSB operators but Pactor operators alike, as well as all communications modes not illustrated in the scenario above. This certainly indicates the need for a *voluntary* band plan to separate communications modes by "gentleman agreements." Such a voluntary band plan is now under construction by the ARRL. Although the FCC Part 97 Rules currently segregate modes into frequency ranges, the FCC Rules unfortunately change too slowly to keep up with the current rapid pace of communications technology. As a result, the narrow space provided for such digital operations have had a crippling effect on any further development because there is no place to operate any such new modes.

Conclusion: Unlike the scenario discussed in the CQ Communications Inc. comment that discusses potential one-way interference from "semi-automatic digital stations" (Pactor-III or other such high speed digital protocols under local or remote control per Part 97.221) to SSB communications, in reality interference will be mutual due to the nature of HF propagation. However, a flexible *voluntary* band plan, which has been suggested by the ARRL, will keep mutual interference to a minimum while providing the amateur radio community flexibility to more rapidly develop newer and more advanced communications modes. I therefore recommend that the commission adopt RM-11306 and specifically eliminate Part 97.221(c).

Respectfully submitted,

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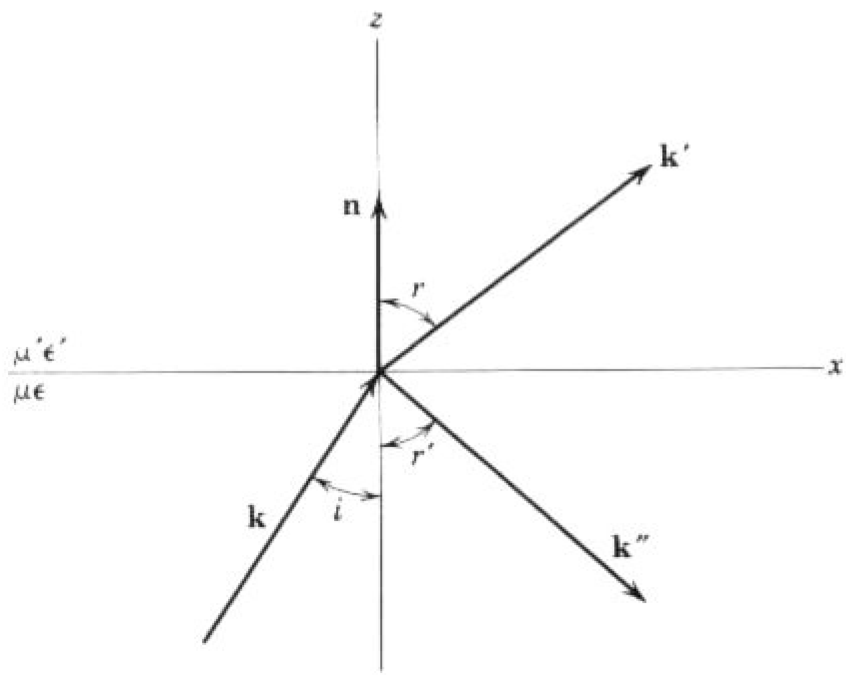
Appendix A. Simplified Model of Propagation in the Ionosphere

The following derivation parallels the general approach used by Dr. J.D. Jackson, Professor of Physics from the University of California, Berkeley, in "Classical Electrodynamics," Second Edition (Wiley, New York, 1975), pp. 292-296. Note that Gaussian units are utilized and all **vectors** are denoted by **bold**. More on this subject can be found at http://ecjones.org/

The simplest approach to describing radio wave propagation is to solve for the index of refraction $\eta = (\mu\ \varepsilon)^{1/2}$, where μ = magnetic permeability (1.25664×10^{-6} H m^{-1}) and ε = dielectric constant. The index of refraction, in turn, describes the relationship between the angles of incidence and refraction through Snell's Law

$$\text{Sin } i \ / \ \text{Sin } r = \eta' \ / \ \eta.$$

This is shown graphically in the figure below which shows an incident wave **k** striking a plane interface between different media, giving rise to a reflected wave **k**" and a refracted wave **k**'.



Since the magnetic permeability is constant in the ionosphere, our goal is to now solve for the dielectric constant from the Equation of Motion, where the dielectric constant is defined as the ratio of the strength of an electric field in a vacuum to that in the ionosphere.

We now consider a simple problem of tenuous electron plasma of uniform density trapped in a strong, static, and uniform magnetic induction **Bo**. If we assume that the transverse radio waves propagate parallel to **Bo**, the

Equation of Motion for electrons trapped in this ionospheric plasma is given by

$$m\, \delta^2\mathbf{x}/\delta t^2 - e/c\, \mathbf{Bo} \times \delta\mathbf{x}/\delta t = -e\, \mathbf{E}\, e^{-i\omega t} ,$$

where the influence of the **B** field of the transverse wave has been neglected compared to the static induction **Bo** and the electron charge is given by -e. It is now customary to describe the electric field component of the radio waves as circularly polarized which implies

$$\mathbf{E} = (\boldsymbol{\varepsilon}_1 \pm i\boldsymbol{\varepsilon}_2)\, E$$

and a similar expression for **x**. Since **Bo** is orthogonal to both $\boldsymbol{\varepsilon}_1$ and $\boldsymbol{\varepsilon}_2$, the cross product in our Equation of Motion has components only in the directions $\boldsymbol{\varepsilon}_1$ and $\boldsymbol{\varepsilon}_2$; therefore, the transverse components decouple. This leads to a steady-state solution given by

$$\mathbf{x} = e\, \mathbf{E} / m\, \omega\, (\omega \mp \omega_B) ,$$

where ω_B is the frequency of precession of a charged particle in a magnetic field which is given by

$$\omega_B = e\, Bo / mc \sim 6 \times 10^6\ \mathrm{sec}^{-1} \text{ (in the earth's magnetic field of Bo=0.3 gauss).}$$

The frequency dependence of our steady-state solution can be determined by transforming our Equation of Motion to a coordinate system precessing with frequency ω_B about the direction of **Bo**. If the static magnetic field is neglected, the force on the electrons has an effective frequency ($\omega \pm \omega_B$), depending on the sign of the circular polarization.

The steady-state solution implies a dipole moment for each electron and yields, for a bulk sample, the dielectric constant of the ionosphere

$$\varepsilon_{\mp} = 1 - \{\omega_p^2 / \omega(\omega \mp \omega_B)\},$$

where the upper sign corresponds to a positive helicity wave (left-handed circular polarization in optics notation), while the lower sign corresponds to negative helicity. Furthermore, ω is the frequency of our radio wave of interest and ω_p is the plasma frequency of the ionosphere and it is given by

$$\omega_p^2 = 4\pi\, NZ\, e^2 / m ,$$

where NZ is the density of electrons per unit volume. For propagation antiparallel to the magnetic field **Bo**, the signs are reversed. Furthermore, for propagation in directions other than (anti)parallel to the static field **Bo**, it is straight forward to show that, if terms of order ω_B^2 are neglected compared to ω^2 and $\omega\omega_B$, the dielectric constant is still given by $\varepsilon_{\mp}$ above.

In this simplified problem of ionospheric radio wave propagation, we see the essential characteristic that waves of right-handed and left-handed circular polarizations propagate differently. In other words, ***the ionosphere has both birefringent and anisotropic propagation properties.***